

62/525, 524, 504, 595

10/734509

165/174, 173, 172, 171

What is claimed is:

5,440,894 ; 6490877 ; 5947195

1. A high reliability heat-exchange structure for a thermal chamber comprising:

a multi-tube cluster including at least three adjacent parallel tubes configured from a continuous length of each tube formed in a grill-like array pattern of end-folded generally horizontal rows located in at least one plane approximating a wall location in the thermal chamber, (each tube being made readily user-selectable for and capable of deployment in performance of a designated heat exchange process in the chamber, independent of the other tubes, involving flow-through of a fluid selected from a group including a liquid, a gas and a transitional combination thereof.

2. The high reliability heat-exchange structure as defined in claim 1 wherein each tube of the structure is made and arranged to be capable of operation as a refrigeration evaporator for refrigerating the chamber, independent of the other tubes, in consequence of flow-through of a refrigerant fluid supplied as input to the tube in pressurized liquid state, evaporating within the tube so as to create and maintain a lowered temperature in the chamber, and exiting the tube in a gaseous state.

3. The high reliability heat-exchange structure as defined in claim 1 wherein, in cross-sectional shape, the tubes in the multi-tube cluster are attached together side-by-side so as to form a flat multi-tube strip, and wherein each tube extends continuously from a first end of the multi-tube strip to a second end thereof.

4. The high reliability heat-exchange structure as defined in claim 3 wherein the multi-tube strip is shaped to form an array of adjacent rows disposed in at least one vertical plane parallel to a corresponding wall of the chamber and contained within a predetermined outline, each row being shaped at ends thereof to fold back in marginal regions of the outline in a manner to form the array of adjacent rows.

5. The high reliability thermal-exchange structure as defined in claim 3 further comprising:

a first valve-manifold comprising a plurality of tube ports, one for each tube in the multi-tube strip, located at the first end of the multi-tube strip, each tube port being connected in fluid communication with a first end of a corresponding tube;

a second valve-manifold comprising a plurality of tube ports, one for each tube in the multi-tube strip, located at the second end of the multi-tube strip, each tube port being connected in fluid communication with a second end of a corresponding tube;

said first and second valve-manifolds each comprising at least one source port and a plurality of on/off valves in a predetermined fluid communication pattern with the tube ports and the source port(s) such as to enable a designated selection of fluid communication links between the tube ports and the source port(s) via corresponding combinations of settings of the on/off valves.

6. The high reliability thermal-exchange structure as defined in claim 3 wherein the multi-tube strip comprises three parallel tubes.

7. The high reliability thermal-exchange structure as defined in claim 5 wherein:

said multi-tube strip comprises three parallel tubes; and.

said first and second valve-manifolds each comprise three tube ports and two source ports.

8. The high reliability thermal-exchange structure as defined in claim 7 wherein said first and second valve-manifolds each further comprise six on-off valves arranged and connected to provide interruptable fluid communication between each of the three tube ports and each of the two source ports

9. The high reliability thermal-exchange structure as defined in claim 2 wherein at least one of the tubes is connected in fluid communication with a refrigeration source including a condenser receiving refrigerant fluid from a compressor, a first end of the tube(s) being connected to the condenser via a high pressure line,

and a second and opposite end of the tube(s) being connected to the compressor via a low pressure/suction line, so as to form in combination a refrigeration system with loop circulation capable of creating and maintaining a lowered temperature in the chamber.

10. The high reliability thermal-exchange structure as defined in claim 5 wherein said first and second valve-manifolds are connected in fluid communication with a refrigeration source including a condenser receiving refrigerant fluid from a compressor, the first valve-manifold receiving liquid refrigerant via a source port thereof through a high pressure line from the condenser, and the second valve-manifold receiving sending gaseous refrigerant via a source port thereof through a low pressure/suction line to the compressor, the on/off valves being set so as to operatively connect two opposite ends of a designated tube to the two source ports respectively, thus forming a refrigeration system with loop circulation capable of creating and maintaining a lowered temperature in the chamber due to evaporation in the tube.